REMARKS

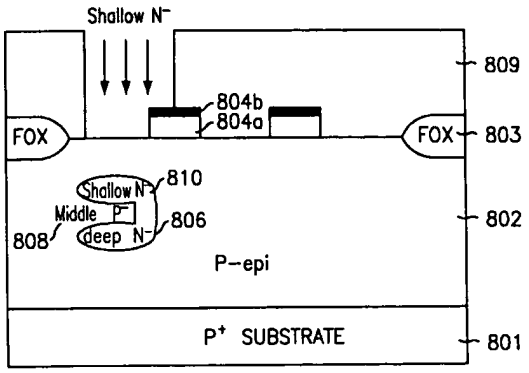
Claims 4, 5, and 35 have been amended. No new matter has been added. Claims 1-13, 15-37, 55, and 56 remain pending in this application. Applicant reserves the right to pursue the original claims and other claims in this or other applications.

Claims 4, 5, and 35-37 stand rejected under 35 U.S.C. § 112, second paragraph as being indefinite. Claims 4, 5, and 35 have been amended to cure their deficiencies.

Claim 55 stands rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,489,643 to Lee. The rejection is respectfully traversed.

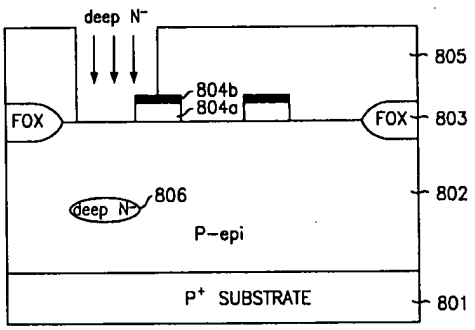
Claim 55 recites a pixel cell for an image sensor, the pixel cell comprising "a photodiode for ... amplifying the generated charge, ... formed within a substrate and below an upper surface thereof ... comprising at least two of a first layer having a first band gap and at least two of a second layer having a second band gap, wherein the first layers are alternated with the second layers." Lee does not disclose, teach, or suggest each of the above limitations.

Lee fails to disclose, teach, or suggest "a photodiode ... comprising at least two of a first layer having a first band gap" and "at least two of a second layer having a second band gap." The Office Action states that the limitation "at least two of a first[/second] layer" is satisfied alternatively by elements 806 and 810, or 808 and 805 of Lee. Office Action, p. 3. The Office Action's reliance is misplaced. Elements 806 and 810 cannot be "at least two of a first[/second] layer" as Lee clearly discloses "two first doping regions of a second conductivity type alternatively formed in the semiconductor layer and *connected to each other at edges thereof* so that the first doping regions have the same potential." Lee, col. 2, ll. 19-22 (emphasis added); FIG. 8D (reproduced below). Formation of "an inclined U-shaped N- doping region" is not "at least two of a first[/second] layer having a first band gap" as recited by claim 55. Lee, col. 4, ll. 57-8.

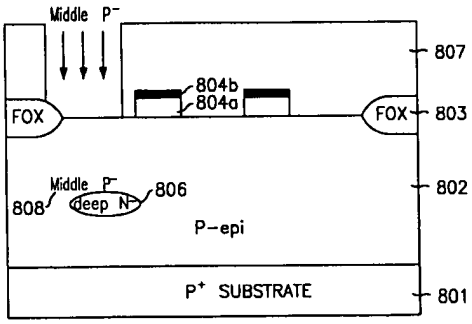


Lee, FIG. 8D

Additionally, Elements 808 and 805 cannot be "at least two of a first[/second] layer." First, element 805 is not present with element 808, as element 808 has not been generated prior to the use of Lee's element 805 as an "N- ion implantation mask." Second, element 805 is only present temporarily for implantation before Lee discloses "removing N- ion implantation mask 805, forming a P- ion implantation mask 807." Lee, col. 5, ll. 44-58; FIGS. 8B, 8C.



Lee, FIG 8B



Lee, FIG. 8C

Furthermore, even if Lee discloses what the Office Action asserts regarding elements 805 and 808 – which Applicant disputes – Lee does not disclose, teach, or suggest "a photodiode ... formed within a substrate and below an upper surface thereof ... comprising at least two of a first layer ... and at least two of a second layer." The Office Action cites elements 802 and 801 as the substrate element of claim 55. Office Action, p. 3. As such, element 805 – cited as being one of the

four layers – is above the substrate (802, 801), and is not "formed within a substrate and below an upper surface thereof" as recited by claim 55. Lee, FIG. 8B (reproduced above).

Moreover, for the same reasons presented above with respect to elements 806 and 810 – that these elements are "connected to each other" – Lee does not disclose, teach, or suggest "the first layers [being] alternated with the second layers." When a layer is "connected," as stated by Lee, the layer cannot also be "alternated with the second layer" as recited by claim 55.

Finally, Lee does not disclose, teach, or suggest "a photodiode for ... amplifying the generated charge" as recited by claim 55. The present invention seeks to improve on a method whereby the electrical charge generated by incident light is amplified. Specification, ¶ 0007. Avalanche photodiodes amplify charge, but the amplification process may also produce noise. *Id.*, ¶ 0009. As such, the present application seeks to provide devices capable of charge amplification, but also with reduced noise for minimized dark current. *Id.*, ¶ 0012. Lee, in contrast, seeks to increase "depletion depth [to increase] the quantum efficiency, thereby producing excellent light sensitivity." Lee, col. 1, ll. 28-29. In fact, Lee makes no reference to charge amplification within the disclosure. As such, Lee does not disclose, teach, or suggest "a photodiode ... for amplifying the generated charge." Therefore, Lee does not disclose, teach, or suggest all of the limitations of claim 55. Applicant submits that, for at least these reasons, claim 55 is allowable over Lee. Accordingly, Applicant respectfully requests the rejection be withdrawn, and the claim allowed.

Claims 1, 4, 11, 15-18, and 56 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,489,643 to Lee in view of U.S. Publication No. 2002/0171077 to Chu. The rejection is respectfully traversed.

Claim 1 recites each of the limitations presented for claim 55. Claim 56 recites each of the limitations presented for claim 55 except for the limitation "formed within a substrate and below an upper surface thereof." Chu is cited as disclosing "a photodiode and a graded buffer layer beneath a bottom layer of the photodiode" for both claims 1 and 56, and fails to cure the deficiencies of Lee. Office Action, pp. 4-6. Claim 1, for at least the reasons presented for claim 55,

is allowable over the cited combination. Claims 4, 11, and 15-18 depend from claim 1 and are allowable along with claim 1, and on their own merits. Claim 56, for at least the reasons presented for claim 55 excepting those reasons regarding the limitation "[a] photodiode being formed within a substrate and below an upper surface thereof," is allowable over the cited combination. Accordingly, Applicant respectfully requests the rejection be withdrawn, and the claims allowed.

Claim 19 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,489,643 to Lee in view of U.S. Publication No. 2002/0171077 to Chu and U.S. Patent No. 6,232,626 to Rhodes. The rejection is respectfully traversed.

Claim 19 depends from claim 1, and is allowable for all the reasons presented for claim 1, and on its own merits. Rhodes is cited as disclosing a pixel cell where the substrate is a silicon-on-insulator substrate, and fails to cure the deficiencies of Lee. Office Action, p. 7. Accordingly, Applicant respectfully requests the rejection be withdrawn, and the claim allowed.

Claims 2-3, 5-8, 12-13, 20-29 and 32-34 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,489,643 to Lee in view of U.S. Publication No. 2002/0171077 to Chu and U.S. Patent No. 5,818,322 to Tasumi. The rejection is respectfully traversed.

Claims 2, 3, 5-8, 12, and 13 depend from claim 1 and are allowable along with claim 1, and on their own merits. Tasumi is cited as disclosing the differences between the valence band energies and the conduction band energies, and does not cure the deficiencies of Lee. Office Action, p. 8.

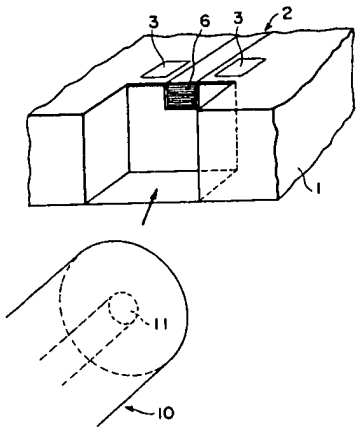
Claim 20 recites similar limitations to those presented for claim 55. Additionally, claim 20 recites "layers [which] are configured such that a difference between conduction band energies of the first and second materials and a difference between the valence band energies of the first and second materials promotes ionization by a first carrier type and suppresses ionization by a second carrier type." The cited combination does not disclose, teach, or suggest each of the limitations of claim 20.

The Office Action has failed to meet its burden of providing a *prima facie* showing of obviousness. The Supreme Court recently stated in *KSR Int'l Co. v. Teleflex Inc.* that "the [Graham] factors continue to define the inquiry that controls" a finding of obviousness. 127 S. Ct. 1727, 1734 (U.S. 2007). The Graham factors include determining the scope and content of the prior art, ascertaining differences between the prior art and the claims at issue, and resolving the level of ordinary skill in the pertinent art. *Graham v. John Deere*, 383 U.S. 1, 148 USPQ 459 (1966).

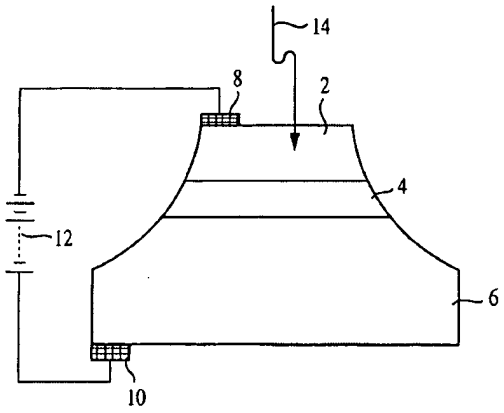
Applicant submits that the Office Action has not properly shown that the Applicant's claims would have been obvious by conducting an examination of the Graham factors. *See* M.P.E.P. § 2141 ("Patent examiners carry the responsibility of making sure that the standard of patentability enunciated by the Supreme Court and by the Congress is applied in each and every case."). Instead, the Office Action merely stated that it "would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Lee to have a difference between the conduction band energies of the first layer and the second materials as in Tasumi in order to improve device characteristics." Office Action, pg. 8. This statement is not an adequate substitution for an analysis of the Graham factors and does not show obviousness.

Indeed, the Office Action admits that Lee does not teach or disclose "the layers configured such that there is a difference between the conduction band energies of the first and second materials and a difference between the valence band energies of the first and second materials." *Id.* The Office Action merely asserts that it "would have been obvious to one of ordinary skill in the art" to allegedly arrive at the claimed invention. *Id.* The Office Action has not applied the proper test for obviousness; accordingly, the Office Action fails to make a *prima facie* case of obviousness. In fact, Tasumi deals with introducing light from a fiber optic cable "in a direction parallel to the wafer surface." Tasumi, col. 1, ll. 64-6; FIG. 2D (reproduced below). In contrast, the present application teaches image sensors formed to maximize light (14) entering absorbing layer(s) (2) at angles substantially perpendicular to the absorbing layer(s) (2). Specification, FIG. 1 (reproduced below). As such, Tasumi teaches away from the present application by orienting its photosensitive element so that entering light may travel through a single layer; the photosensitive element is not oriented such that light must travel through multiple layers.

Without the benefit of hindsight, there would have been no motivation to modify Lee with the layers of Tasumi, and the Office Action has failed to provide proof of any such motivation based on Tasumi or other reasoning.



Tasumi, FIG. 2D



Specification, FIG. 1

Furthermore, even if the references were combinable, which they are not, the cited combination fails to disclose, teach, or suggest "promot[ing] ionization by a first carrier type and suppress[ing] ionization by a second carrier type."

The Office Actions relies on column 5, lines 20-30 of Lee as teaching "promot[ing] ionization by a first carrier type and suppress[ing] ionization by a second carrier type." Lee, as presented above, seeks to increase "depletion depth [to increase] the quantum efficiency, thereby producing excellent light sensitivity." Lee, col. 1, ll. 28-29. Lee, in order to improve light sensitivity, discloses "increased capacity to save photogenerated charges [to make] it possible to obtain the desired quantum efficiency." Lee, col. 5, ll. 23-25. The complete implantation of the "middle P- doping region 708, deep N- doping region 706 and shallow N- doping region 710 ... further increas[es] the collection area for photogenerated charges and obtain[s] the quantum efficiency image which the sensor requires." Lee, col. 5, ll. 26-31. This disclosure, however, in no way teaches "promot[ing] ionization by a first carrier type and suppress[ing] ionization by a second carrier type." In short, teaching a method to increase sensitivity does not disclose the ability to

discriminate between carrier types. As such, the cited combination does not disclose, teach, or suggest "promot[ing] ionization by a first carrier type and suppress[ing] ionization by a second carrier type." Therefore, the cited combination does not disclose, teach, or suggest all of the limitations of claim 20. Applicant submits that, for at least these reasons, claim 20 is allowable over the cited combination. Claims 21 – 29 depend from claim 20 and are allowable along with claim 20, and on their own merits.

Claim 32 recites an image sensor comprising "a photodiode formed below an upper surface of a substrate, the photodiode comprising at least two layers of Si alternating with at least two layers of Si_xGe_{1-x}." The cited combination does not disclose, teach, or suggest each of the limitations of claim 32.

For at least the reasons presented with respect to claim 20, Lee and Tasumi are not combinable. Even if the references were combinable, which they are not, the cited combination fails to disclose, teach, or suggest "a photodiode formed below an upper surface of a substrate, the photodiode comprising at least two layers of Si alternating with at least two layers of Si_xGe_{1-x}."

For at least the reasons presented previously for claim 55, Lee does not disclose, teach, or suggest "a photodiode formed below an upper surface of a substrate, the photodiode comprising at least two layers ... alternating with at least two layers." Chu is cited as disclosing a photodiode and a graded buffer layer beneath a bottom layer of the photodiode, and does not cure the deficiencies of Lee. Office Action, p. 12. Tasumi is cited as teaching (a) a photodiode structure with alternating layers of Si and Si_xGe_{1-x}, where x is .6, formed in the groove of the photodiode, and (b) the layers of Si being doped to a first conductivity type and the layers of SiGe being doped to a second conductivity type. *Id.* Despite these teachings, Tasumi does not cure the deficiencies of Lee. Therefore, the references alone, or in combination, do not disclose, teach, or suggest all of the limitations of claim 32. Applicant submits that, for at least these reasons, claim 32 is allowable over the cited combination. Claims 33 and 34 depend from claim 32 and are allowable for all the reasons presented for claim 32, and on their own merits. Accordingly, Applicant respectfully requests the rejection be withdrawn, and the claims allowed.

Claims 30, 31, and 35-37 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,489,643 to Lee in view of U.S. Publication No. 2002/0171077 to Chu, U.S. Patent No. 5,818,322 to Tasumi, and U.S. Patent No. 6,232,626 to Rhodes.

Claims 30 and 31 depend from claim 20 and are allowable for all the reasons presented for claim 20, and on their own merits. Rhodes, for claim 30, is cited as disclosing readout circuitry connected to a floating diffusion region for reading out charge, and fails to cure the deficiencies of Lee. Office Action, p. 6. Rhodes, for claim 31, is cited as disclosing circuitry peripheral to the array, the peripheral circuitry being at a surface of the substrate where the substrate is silicon-on-insulator, and fails to cure the deficiencies of Lee. *Id.*

Claim 35 recites limitations similar to those presented for claim 20, and is allowable for all the reasons presented for claim 20, and on its own merits. Rhodes, for claim 35, is cited as disclosing a processor system including a processor coupled to the image sensor and with readout circuitry electrically connected to the floating diffusion region, and fails to cure the deficiencies of Lee. Office Action, p. 15. Therefore, the cited combination does not disclose, teach, or suggest all of the limitations of claim 35. Applicant submits that, for at least these reasons, claim 35 is allowable over the cited combination. Claims 36 and 37 depend from claim 35 and are allowable along with claim 35, and on their own merits. Accordingly, Applicant respectfully requests the rejection be withdrawn, and the claims allowed.

In view of the above, Applicant believes the pending application is in condition for allowance.

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Respectfully submitted,

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